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ODD description methods for automated driving vehicle and verifiability for safety

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Abstract: There is no standard method for describing the Operational Design Domain (ODD) in automated driving vehicles. There are many elements in the operating domain, including the external environment, and it is necessary to connect them with the internal state of the automated driving system. Its content ultimately requires the user's understanding. The description method of this ODD is summarised from the aspect of safety. Consistency with standards and guidelines will also be considered.

Keywords: Safety, Operational Design Domain (ODD), Automated Driving System (ADS), Autonomous Car
Categories: D.2, H.1
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1 Introduction

The description of the Operational Design Domain (ODD) for autonomous vehicles is an essential description for ensuring the safety of autonomous vehicles [SAE, 21]. ODD is a conditional area in which the vehicle can operate the Automated Driving System (ADS). Especially at SAE Level 3 and above, it is an important factor. However, there is currently no clear answer as to how to describe ODD.

For example, suppose you have a Level 3 feature called Traffic Jam Drive [NHTSA, 18]. The vehicle equipped with this ADS can automatically maintain the inter-vehicle distance on the highway during traffic jams. The ODD of this car will be as follows: the vehicle speed is low on the highway and the weather does not interfere with the radar function. Whether or not this ODD description is appropriate from the viewpoint of safety is the subject of this paper.

We have conducted various studies on autonomous vehicles, mainly on safety [Ito, 17, 18, 19, 20]. ODD is an essential description for autonomous vehicles, but we believe that a clear definition is vital to ensure safety. In this paper, we consider the ODD description concerning the illustration shown in existing standards and documents.

The definition of the ODD is: "*operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and / or the requisite presence or absence of certain traffic or roadway characteristics*" [SAE, 21].

In this definition, the ODD is the operating condition of an automated system or its feature. We can define the function of ADS by pairing it with ODD. We can also find examples of specific operating conditions: environmental, geographical, and time-of-day restrictions. That is, the elements existing outside the system define the behaviour of ADS. Therefore, we can define the boundaries of ODD using the characteristics and presence/absence of elements outside the system.

To observe more about the ODD, we also see two notes in J3016. The first is from NOTE 1 to 3 in 3.9.

NOTE 1: A given driving automation system may have multiple features, each associated with a particular level of driving automation and ODD.

NOTE 2: Each feature satisfies a usage specification.

NOTE 3: Features may be referred to by generic names (e.g., automated parking) or proprietary names.

The second is a note from 3.28 of J3016:

NOTE: Each feature satisfies a usage specification.

From the above definitions, we can get the conceptual diagram shown in Figure 1.

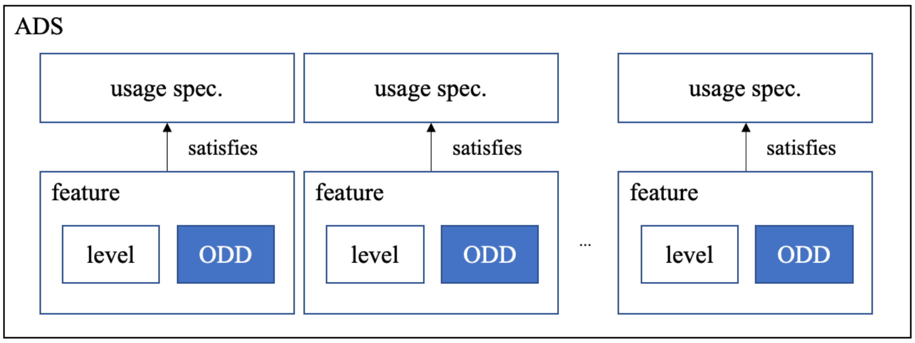

Figure 1: ADS, feature and ODD (created from SAE J3016 3.9, 3.28)

The ADS has one or more features and is represented by a set of levels and ODD. Therefore, it may have multiple ODDs for the multi-featured case. We also have another explanation that a single ODD has a different subset (e.g., UL 4600). It corresponds to the following sentence: "*a given driving automation system feature has only one ODD, but that ODD may be quite varied and multi-faceted*" (p.33 in [SAE, 21]).

Figure 2 shows another view of the conceptual ODD.

An R_{ODD} shows normal operating conditions where the ADS operates. It does not work on the outside. Also, it is inappropriate to stop working discontinuously in ODD. Before exiting R_{ODD} (ODD EXIT), it may be necessary to behave differently from the DDT (Dynamic Driving Task) which was originally expected as an ADS feature; the notification to passenger and/or DDT fallback and subsequent execution for Minimum Risk Condition (MRC). R_{ODD}- shows the ODD region, considering the time required for behaviour associated with the transition. R_{ODD}+ indicates an area that includes a design margin as a margin from the viewpoint of safety. R_{ROD} shows the area where a specific function can be executed as ADS even if some functional failure occurs. This area can be used as a risk aversion separately from the MRC [Colwell, 18].

Also, as mentioned above, one ODD is determined for each ADS feature. A complex ADS could have multiple features, and there are multiple corresponding

ODDs. The UL 4600 standard [UL4600 2020], described below, uses the term subset rather than multiple ODDs.

BSI PAS-1883 [BSI, 20], a specification for ODD, which also will be described later, asserts as follows: It is necessary to "create a definition of ODD for safe operation and to be agreed by stakeholders individually or in consultation. ... Stakeholders here include local governments, regulators, service providers, manufacturers, ADS developers, or component and subcomponent suppliers (0, p.4 "4 ODD requirements and application").

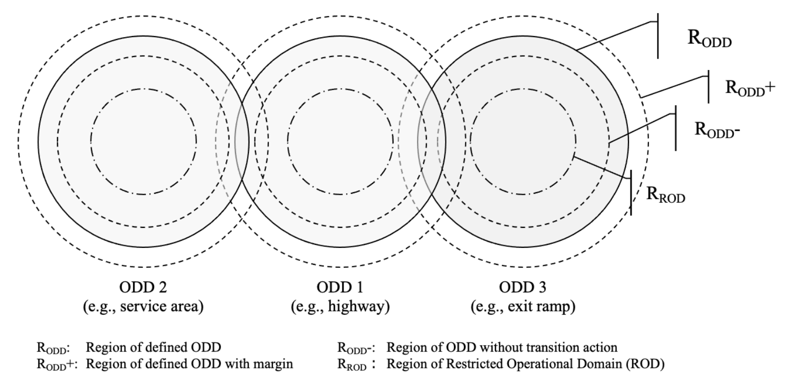

Figure 2: Various abstract ranges of ODDs

There are various regulations regarding ODD in recent years. Although not exhaustive, this paper deals with the following four typical documents (see Table 1).

There are other standards in progress. A representative standard in progress is ISO /AWI 34503 (Road vehicles — Taxonomy for operational design domain for automated driving systems) [ISO, 21]. At UNECE, discussions on ODD are underway in the Functional Requirements for Automated Vehicles (FRAV) [UNECE, 21]. Since there is little public information, it will not be dealt with in this paper.

In Table 1, the first document is the Publicly Available Specification (PAS) of the British Standards Institution. It says that "*providing ODD is the first step in providing "informed safety" to end-users ... we are seeking stakeholder consensus just for "informed safety."*"

ID	Name	Target SAE Level	Characteristics	Top level attrib.
(1)	BSI PAS 1883	3, 4	– Emphasizes the relationship between stakeholders and ODD	Scenery, Environment condition, Dynamic elements

(2)	WISE	4, 5	– High affinity with ISO26262. – OREM (see 2.2) can represent the inside and outside of ODD	Road structure, Road users, Animals, Other obstacles, Environmental Conditions
(3)	AVSC	4	– Uses conceptual framework (bottom-up approach) to define ODD – Defines lexicon for communication among stakeholders	Weather-Related Environmental Conditions, Road Surface Conditions, Roadway Infrastructure, Operational Constraints, Road Users, Non-Static Roadside Objects, Connectivity
(4)	OpenODD	-	– Description is machine-readable for simulation	-

Table 1: Recent guideline documents for ODD description

The second document is the research results of the Waterloo Intelligent Systems Engineering Lab (WISE Lab) at the University of Waterloo. Documents related to ODD include WISE Requirements Analysis Framework for Automated Driving Systems, Operational World Model Ontology for Automated Driving Systems. Part 1 is a description of Road Structure, and Part 2 is a description of Road Users and Environmental Conditions. As the title suggests, it is possible to create an operational world model using an ontology and define ODD using that expression. The latest version was published in July 2018.

The third document is the result of SAE ITC's Automated Vehicle Safety Consortium (AVSC). ODD is defined using a conceptual framework and a lexicon. It says that the ADS manufacturers "*(have) to describe their products' ODD with enough specificity to not only satisfy customer expectations, but also the needs of regulators and road operators.*"

The last document is one of the activity materials in OpenODD. OpenODD is an ongoing project, and no final results have been published yet. We check the contents of the initial workshop “Ideation Workshop ASAM ODD”.

When considering the safety of ADS, the precise definition of ODD is essential, but as is clear from the multiple discussions above, there is no single agreed description method currently.

In the next chapter, we will briefly examine the description method proposed in the above document. Chapter 3 examines the relationship between ODD and verifiability. Here, we consider a method for improving verifiability using UL4600. Then we will discuss the results obtained and summarize them at the end. In this paper, ADS-DV (Automated Driving System – Dedicated Vehicles) is the main target.

2 Various ODD descriptions

Generally, as defined in J3016, the description is divided into categories such as environment and geography. Currently, there is no fully agreed categorization. It is also unclear whether unified categorization is possible. This is because the automation function requires a category for description according to the function. For example, only automation using GSNN (Global Navigation Satellite System) requires how to describe the operating conditions of GSNN.

In each section, we summarize the ODD description method for each document shown in Table 1. If there is a characteristic description element, we also describe it.

2.1 BSI PAS 1883

ODD has a hierarchical structure shown in Table 2. First, it has three attributes: "Scenery", "Environmental conditions", and Dynamic elements. The "Scenery" attribute is an immovable element of the operating environment, for example, roads and traffic lights. The "Environmental conditions" attribute includes meteorological conditions atmospheric conditions, and so on. The "Dynamic elements" attribute indicates traffic conditions and the subject vehicle.

Top Level Taxonomy	Attributes	# of sub attributes
Scenery	Zones	5
	Drivable area	6
	Junctions	2
	Special Structures	6
	Fixed road structures	4
	Temporary road structures	4
Environmental conditions	Weather	3
	Particulates	5
	Illumination	4
	Connectivity	2
Dynamic elements	Traffic	5
	Subject vehicle	1

Table 2: BSI PAS 1883 taxonomy (3rd level shows only the number of attributes)

Each attribute has more detailed sub-attributes. For example, "Scenery" attributes are decomposed as follows:

A) zones
B) drivable area
C) junctions
D) special structures
E) fixed road structures
F) temporary road structures

Attributes are further subdivided into lower-level attributes. The attributes of "zone" are as follows:

A1) geo-fenced areas
A2) traffic management zones
A3) school zones
A4) regions or states
A5) interference zones (e.g., dense foliage or loss of positioning signal due to tall buildings.)

Junction (C) has three attributes: Roundabout, presence/absence of signal, and Intersection. Furthermore, Roundabout has five attributes such as normal and compact. Therefore, Roundabout and the presence/absence of a signal have orthogonal attributes. Many of the attributes are not exclusive.

Like other documents, it uses the enumeration method. Easy to understand is an advantage, but it cannot be covered entirely.

Also, since it is a British standard, roundabouts are classified in detail. The attributes of roads to be refined differ from country to country.

2.2 WISE

WISE uses an ontological approach. The conceptual relationship shown by the ontology is a hierarchical manner. The top-level is divided into five categories as follows:

- Road structure
- Road users
- Animals
- Other obstacles
- Environmental conditions

Top Level	2nd Level
Road structure	road type and capacity
	road surface type and quality
	road geometry
	cross-section design
	traffic Control devices
	pedestrian crossing facilities
	cycling facilities
	junctions
	railroad level crossings
	bridges
	tunnels
	driveways
	temporary road structure

Top Level	2nd Level
Road users	ground vehicles, including their occupants
	animal riders
	pedestrians
	traffic control persons
Animals	small
	medium-size
	large
Other obstacles	-
Environ-mental conditions	atmospheric conditions
	lighting conditions
	road surface conditions

Table 3: WISE, Top level and 2nd level class

Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden. shows up to the second level class. These are categorized in detail and given definitions. Like BSI PAS 1883, WISE can obtain ODD as an instance for an item by giving a value to each terminal attribute.

What is interesting about WISE's approach is the Operational Road Environment Model (OREM). OREM is a model related to the road environment in which ADS-equipped vehicles travel. For example, it consists of a specific road, such as a two-lane country road or a highway ramp. As an expression, it can be in the form of a specification or any executable model.

Generally, the scenario is expressed using multiple ODDs. In WISE, there is a difference in expressing ODD using OREM.

2.3 AVSC

AVSC aims to practically define ADS-DV using a conceptual framework and a lexicon [AVSC, 20].

Top Level	2nd Level	3rd Level
Weather-related Environmental Conditions	Temperature	-
	Precipitation Types	10
	Haze	-
	Sky condition	-
	Illuminance	-
	Sun angle	-
	Wind	-
Road Surface Conditions	State of Repair	5
	Quality of Road Markings	-
	Road Surface Obscurants	7
	Transient Roadway Obstacles	-
Operational Constraints	Rush Hour	-
	Intended Operational Times	-
	Zones	2
Road Users	-	10
Non-Static Roadside Obj.	-	-
Connectivity	Fleet Management	-
	Obstructions	-
Roadway Infrastructure	Road Network	-
	Road Network	-
	(Roadway) Sight Distance	-
	(Roadway) Grade	-
	(Roadway) Superelevation	-
	(Road) Vertical Curvature	-
	(Road) Horizontal Curvature	-
	Ramps	-
	Intersections	-
	Geofenced Area	-
	Traffic Control Devices	-
	Design Elements	7
	Lane	4
	Shoulder	-
	Curb	-
	Weaving Section	-
	On-Street Parking	-

Table 4: AVSC lexicon

For example, BSI PAS 1883 (see 2.1) uses a bottom-up approach, but AVSC takes a bottom-up approach. First, determine the target area. By covering the routes within that range, the necessary elements ("lexicon") and parameters are defined. The categories used are as follows.

- Weather-related environmental conditions (temperature, precipitation, etc.)
- Road surface conditions (state of repair, marking, etc.)
- Road structures (road network, type, etc.)

- Operation restrictions (congestion status, intended time zone, etc.)
- Road users (cars, bicycles, pedestrians, etc.)
- Objects along non-steady roads
- Connectivity (GNSS, communication failure, etc.)

As mentioned before, there are many stakeholders in ODD. So, the lexicon is meaningful for mutual understanding. By unifying the terms, we might communicate with each other more correctly about ODD.

The final ODD can be expressed in tabular form or descriptively as a natural language sentence, just like any other.

A more detailed lexicon is in Table 4Table 4. The 3rd Level column shows only the number of the third level elements.

ODD Category	Explicitly within ODD	Explicitly Outside ODD
Route Network	Downtown Detroit, Michigan see map boundaries	Area around Detroit Police Department and Department of Public Safety see map boundaries
Sun Angle	Apparent sunrise/sunset (sun at or above the horizon)	
Precipitation	Light rain and light snow (*provided road surface conditions are not exceeded)*	Mist, Fog (severity 5)
Operating speed	≤35mph	
Wind	Up to strong breeze (31 mph)	
Lane width	≥12ft	
Road surface conditions	Wet or dry	No standing water; not snow covered
Connectivity	Cellular connection required	
Rush hour	Yes	

Table 5: AVSC tabular expression example

Another way for mutual understanding is the conversion to descriptive expressions. The automatic replacement may be easier to understand for some stakeholders. Also, because of the different ODD representations, it may be possible to find simple errors.

The narrative text in Figure 3 was transformed from the tabular expression in *Table 5*. The original is Appendix B in [AVSC, 20]. The correspondence between the tabular expression and the descriptive one is expressed using colours. Part of the original description of has been changed for consistency.

The system is designed to operate on the road network in the urban center of Detroit, Michigan on all streets with a speed limit of 35mph or less. Its boundary is constrained by I-75 to the north; I-375 to the east; M-10 to the west; and Atwater Street along the Detroit River to the south. The areas around the Detroit Police Department and Department of Public Safety are excluded from this ODD. The system is capable of operating during daylight hours when the sun is at or above the horizon. It can operate in fair weather, including wind gusts up to 31 mph, light rain, and light snow, provided the road surface is not covered by snow nor standing water. It recognizes and understands all signage and traffic control devices inside this ODD. Work zones are coordinated with the local transportation department and excluded from the route network as needed.
And the System needs cellular connection.

Figure 3: AVSC narrative expression example

As we can see from the actual correspondence, not all the contents of the table turns into narrative sentences. For example, the description of rush hour is applicable. Rush hour availability means you can always use it. Therefore, adding the description in a narrative form can be misleading.

Moreover, it is not easy to replace the map representation with a document. Therefore, the table and the descriptive expression do not correspond completely. Map references are required for both representations.

2.4 OpenODD

OpenODD is a kind of model-based approach because it uses a domain-specific language (DSL) [ASAM, 21]. OpenODD does not have strict semantics but has the advantage of being able to machine. The aim is to use it in simulations.

```
default is permissive
global definitions
        for GenericTrafficDensity we allow [LowTrafficDensity, MediumTrafficDensity]

        for ActiveRoadState attribute PertinentSceneElements we do not allow [LearnerOrNewDriverCar,
                WideLoadLorry,
                ArticulatedBus,
                EmergencyVehicle,
                Cyclist,
                HorseRider,
                NonRoadRespectingObjects]
        for AirParticlateMatter we allow [ClearAir]
        for WeatherCondition we allow [ClearCalm, LightRain]
        for TimeOfDay we allow [DayLight]
        for WindLevel we do not allow [StrongWinds]
        for GroundCondition we allow [DryGround, WetGround]
        for AlteredCondition we do not allow anything
```

Figure 4: Example of an ODD definition by OpenODD

Other provisions are being created in parallel. OpenDrive is a static road regulation. We can use OpenScenario to describe dynamic scenarios and use OpenCRG to define road surface conditions.

The activity has just started, and there is no specific provision for OpenODD. Figure 4 shows an example of the description method being studied based on the workshop material [Whiteside, 20].

The global definition indicates whether each attribute is inside the ODD ("*we allow*") or outside the ODD ("*we do not allow*"). For example, the strong wind is outside the ODD (third line from the bottom). The road surface condition is within ODD in both dry and wet conditions (second line from the bottom), and attributes not described are unconditionally not allowed (last line).

3 Verifiability

Verification means that the realization satisfies the specification, and verifiability means that the specification and the realization have sufficient information to show the sufficiency. That is, it is possible to judge whether the specifications are satisfied. The IEEE definition for verifiability is as follows: "*Verifiable: The requirement has the means to prove that the system satisfies the specified requirement. Evidence may be collected that proves that the system can satisfy the specified requirement*" [ISO, 11].

There are various verification methods, but there are two main methods: testing and formal verification [Ito, 16]. The test is further divided according to the extent to which other elements are used for the test target, the model alone, the combination with other software, and the combination with the actual hardware. There is also a classification of whether to execute in a simulation environment or an actual environment. In any case, the test method is to make it work.

The other is a method called formal verification. It is a method to confirm whether the realization satisfies the specifications based on some mathematical model. There is no need to operate ADS.

There are three main methods of formal verification approaches (e.g. [Todorov, 18]).

- Model checking
- Deductive approach
- Abstract interpretation

Realization does not necessarily have to be an implementation (program). Realization of a specification is, for example, a design result for the specification. Formal verification is possible if both have a machine-processable format.

We are currently trying formal verification, including ODD, based on a deductive approach in formal verification, outside the scope of this paper.

Now, whatever verification method is used, it must be verifiable. That is, the specifications and realizations must be accurate and accurate enough to show satisfiability. For this evaluation, we use the UL 4600 [UL, 20] standard. UL 4600 uses a safety case as a tool to demonstrate its argument. Of course, the safety case itself has no mechanism for demonstrating. It is just a framework to show that the argument has been made. The appropriate description is required to apply the safety case, and UL 4600 requires that description.

In the following, we will focus on the mandatory clauses (called the mandatory prompt list) according to the structure of the UL 4600 chapter on ODD.

3.1 Completeness of ODD definition

UL 4600 has the following provisions regarding integrity:

The Operational Design Domain (ODD) shall be defined in an acceptably complete manner. (8.2.1)

The mandatory detailed rules are as follows.

An acceptably complete ODD definition with traceability to ODD-dependent aspects of the safety case

Argue that the item is safe within the ODD

Argue that the item is safe when the ODD has been exited

EXAMPLES: A fault mitigation manoeuvre might exit the ODD intentionally, or a change in environment might force an unexpected ODD exit

UL 4600 justifies safety by using a safety case for all of its requirements: "*The safety case shall be a structured explanation in the form of claims, supported by argument and evidence, that justifies that the item is acceptably safe for a defined operational design domain, and covers the item's lifecycle. (5.1.1).* "

Therefore, the "acceptable and complete method" means that the features given to the item by the item definition ensure acceptable safety when it goes inside or outside the ODD region. It is to show. It should be noted that ODD alone cannot determine whether it is good or not. By following this rule, it is possible to consider whether it is a detailed description level that can be shown in the safety case.

3.2 ODD and environment

The ODD shall cover relevant environmental aspects in which the autonomous item will be operating (8.2.2).

The mandatory elements are as follows.

- *a) Documented definition of the ODD and relevant subsets including coverage of safety aspects*
- *b) Travel infrastructure*
- *c) Object coverage (i.e., objects defined as being within ODD)*
- *d) Event coverage*
- *e) Behavioural rules*
- *f) Environmental effects*
- *g) Operational condition of item*
- *h) Operational duration*

The four descriptions present detailed categories for the environment. However, some elements are not included.

The rules of conduct (e) include traffic regulations. Traffic regulations are not included in the ODD description method. These may be the contents that should be specified as the behaviour t on the OEDR side. For example, take an example from SINGAPORE TR 68 Part I: Autonomous vehicles Part 1: Basic behaviour. The following rule: "*6.5 a) When the pedestrian is standing on the carriageway and facing traffic, an AV shall keep a lateral gap of at least 1 m when passing (FTD 242).*" It may be sufficient to recognize the positional relationship between the object and the vehicle. On the other hand, "6.5 f) An AV shall be able to interpret a cyclist's gesture to move into an AV's path of travel and shall adjust its speed to provide sufficient braking distance behind the cyclist (BTD 166f, FTD 245)". In this case, it is necessary to identify the cyclist's gesture.

	BSI	WISE	AVSC	OpenODD	Notes (Examples)
a) Definition	o	o	o	o	This is expected to take the form of an ODD taxonomy.
b) Infrastructure	o	o	o	o	Types of road surfaces, road geometries...
c) Object Coverage	o	o	o	o	Objects defined as being within ODD
d) Event Coverage	x	x	o	x	Interactions with infrastructure and other objects
e) Behavior rule	x	x	x	x	Traffic laws, vehicle path conflict resolution priority, local customs ...
f) Environment effect	o	o	o	o	Weather, illumination, ...
g) Operational condition	o?	o?	x	o?	Temporary or permanent degradation of ego vehicle equipment
h) Operational duration	x	x	x	x	Mission length, expected system operational life

Table 6: Comparison of four descriptions from the UL4600 perspective

Table 6 shows a comparison between the description methods shown in Chapter 2 and the mandatory elements. The coverage is almost the same. WISE dynamically represents ODD as a set of OREM sets. This point is different from the others.

3.3 ODD violation

<u>*ODD violations shall be handled in an acceptably safe manner. (8.2.3)*</u>

The mandatory elements are as follows.

a) Identify strategy for detecting when item is within bounds of the ODD

b) Identify strategy for risk mitigation while transitioning out of the ODD

The ADS monitors that it is in the ODD. When an ODD EXIT occurs, the ADS needs to change the behaviour of the vehicle. At Level 3, extra time is required to carry out the Request of Intervene (ROI). At Level 4, when Fallback is performed, a margin time is also needed (see R_{ODD-} in Figure 2).

In general, there are multiple ODDs, or they can be subdivided into subcategories. The transition of ODD also requires a similar discussion.

The four notations do not correspond to the requirements of this section.

3.4 ODD changes

<u>*Changes to the ODD shall be detected and tracked to resolution (8.2.4)*</u>

The mandatory elements are as follows.

a) Identify strategy for detecting safety related changes to ODD, including:
  1) New vehicles, elements, characteristics, behaviours, objects, and other ODD aspects
  2) Modifications to characterization of ODD
b) Identify data monitoring source for each type of identified change
c) ODD model subject to configuration management and version control

Each description method emphasizes the need to follow when the road topology etc., changes. However, as shown here, there is no description of the aspect of configuration management.

4 Summary

As the development of ADS becomes active, how to describe ODD, which is the operating condition, becomes more critical. Therefore, many standards and documents have been published or are in progress. This paper first considered ODD and then investigated the ODD description methods specified by the four representative documents currently published.

We considered the verifiability of the ODD description. There is currently no fixed method. Therefore, in this paper, we decided to use the UL 4600 prompt list.

The UL 4600 standard presupposes that we use a safety case. The safety case consists of evidence-based arguments. Therefore, the UL 4600 prompt list requires enough detail to show that its demonstrative structure holds. Therefore, UL4600 is an effective means when considering the verifiability of the ODD.

As a result of the investigation, we found that the current ODD description methods have some deficiencies from the UL4600 point of view. At present, the ODD description method focuses on unified categorization and terminology. Therefore, "ODD and environment (3.2)" has a certain degree of detail, but the configuration management aspects such as ensuring safety due to "ODD violation (3.3)" and "ODD changes (3.4)" will be an issue for the future.

Now, ODD has interesting properties. One is that it is closely related to safety. If the range of ODD is reduced, it becomes easier to ensure safety. However, it is more likely to cross ODD boundaries frequently, affecting end-user comfort. In some cases, it affects safety. Therefore, it is not desirable to keep the ODD within a small range.

On the other side, many stakeholders need to understand ODD correctly. Complex ODD contradicts the end-user's desire to simply desire automated driving. Mutual conversion between tabular and natural language formats in AVSC is one of the solutions to the user's understanding of ODD. Of course, even if the expression of an ODD is changed, if the ODD itself is complicated, the user cannot understand the ODD. Simplifying the ODD itself is of practical importance.

We believe that formal verification will be partially possible in the future as the ODD description develops in a positive direction. As a result, we believe that it will be possible to rationally address issues such as the relationship with safety, ODD design that does not impair comfort, and easy-to-understand the ODD expression.

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